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10-14-04 #5 DAC/$

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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OFFICE OF PETITIONS

APPLICATION NUMBER: 09/882,703

FILING OR 371(c) DATE: 06/14/2001

FIRST NAME APPLICANT: HEINRICH FOLTZ

PETITION TO REVIVE UNDER 37 CFR 137(b)

Dear Sirs;

Pursuant to 37 CFR 1.137 applicant files this petition to revive. In support of this petition applicant shows the following:

1. Applicant's attorney of record miss docketed the correspondence that this office sent on 08/13/2001. This was an oversight on behalf of applicant's attorneys previous law firm. When attorney of record left the law firm all correspondence was being forwarded to him. However, the notice of abandonment that was mailed on 02/o5/2004 was never forwarded to the attorney of record. Since neither applicant nor attorney of record hear any news on the application, on September 8, 2004 applicant through its attorney of record inspected the file wrapper. That is when applicant's attorney found that the above referenced application was abandoned. As soon as applicant found that out this Petition to revive was filed.
2. The entire delay was unintentional on behalf of the applicant and its attorney of record.
3. The petition fee set fort in 37 CFR 1.17(m) 660 dollars is enclosed;
4. Since the application was filed after June 8, 1995, no terminal disclaimer is needed, and
5. The required reply to this notice is attached to this petition

In view of the above applicant requests that the above application be revived since the abandonment was unintentional.

Respectfully Submitted,

Anthony Matulewicz
Patent Reg. No. 45,375.

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COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. 20231
www.uspto.gov

APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
09/882,703	06/14/2001	Heinrich Foltz	

CONFIRMATION NO. 9610

FORMALITIES LETTER

OC000000006413843

ANTHONY MATULEWICZ
SUITE 1111
200 S. TENTH ST.
McALLEN, TX 78501

Date Mailed: 08/13/2001

NOTICE TO FILE CORRECTED APPLICATION PAPERS

Filing Date Granted

This application has been accorded an Application Number and Filing Date. The application, however, is informal since it does not comply with the regulations for the reason(s) indicated below. Applicant is given **TWO MONTHS** from the date of this Notice within which to correct the informalities indicated below. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a)

The required item(s) identified below must be timely submitted to avoid abandonment:

- The Claim(s) commencing on a separate sheet (37 CFR 1.75(h)).
- A substitute specification in compliance with 37 CFR 1.52 because:
  - Line spacing on the specification, claims, or abstract is not 1-1/2 or double spaced (See 37 CFR 1.52(b)).
- Abstract must be on a separate sheet.

A copy of this notice MUST be returned with the reply.

Customer Service Center
Initial Patent Examination Division (703) 308-1202

PART 3 - OFFICE COPY

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
09/882,703	06/14/2001	Heinrich Foltz	

CONFIRMATION NO. 9610

ABANDONMENT/TERMINATION LETTER

OC000000011848086

ANTHONY MATULEWICZ
SUITE 1111
200 S. TENTH ST.
McALLEN, TX 78501

RECEIVED
MAR 03 2004

Date Mailed: 02/05/2004

NOTICE OF ABANDONMENT UNDER 37 CFR 1.53 (f) OR (g)

The above-identified application is abandoned for failure to timely or properly reply to the Notice to File Missing Parts (Notice) mailed on 08/13/2001.

- No reply was received.

A petition to the Commissioner under 37 CFR 1.137 may be filed requesting that the application be revived.

Under 37 CFR 1.137(a), a petition requesting the application be revived on the grounds of **UNAVOIDABLE DELAY** must be filed promptly after the applicant becomes aware of the abandonment and such petition must be accompanied by: (1) an adequate showing of the cause of unavoidable delay; (2) the required reply to the above-identified Notice; (3) the petition fee set forth in 37 CFR 1.17(l); and (4) a terminal disclaimer if required by 37 CFR 1.137(d).

Under 37 CFR 1.137(b), a petition requesting the application be revived on the grounds of **UNINTENTIONAL DELAY** must be filed promptly after applicant becomes aware of the abandonment and such petition must be accompanied by: (1) a statement that the entire delay was unintentional; (2) the required reply to the above-identified Notice; (3) the petition fee set forth in 37 CFR 1.17(m); and (4) a terminal disclaimer if required by 37 CFR 1.137(d).

Any questions concerning petitions to revive should be directed to the "Office of Petitions" at (703) 305-9282.Petitions should be mailed to: Mail Stop Petitions, Commissioner for Patents, P.O. Box 1450, Alexandria VA 22313-1450.

A copy of this notice MUST be returned with the reply.

D. Dunham
Customer Service Center
Initial Patent Examination Division (703) 308-1202

PART 2 - COPY TO BE RETURNED WITH RESPONSE

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OCT 21 2004
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION NUMBER: 09/882,703

FILING OR 371(c) DATE: 06/14/2001

FIRST NAME APPLICANT: HEINRICH FOLTZ

CORRECTION OF APPLICATION PAPERS

Dear Sirs;

Pursuant to your correspondence dated 08/13/2001 enclosed you will find a substitute application where:

1. The claims are commencing on a separate sheet; and
2. A substitute specification in compliance with 37 CFR 1.136(a), and
3. The abstract on a separate sheet.

Respectfully Submitted,

Anthony Matulewicz
Patent Reg. No. 45,375.

OIPE JC95
OCT 12 2004
PATENT & TRADEMARK OFFICE

RECEIVED
OCT 21 2004
OFFICE OF PETITIONS

MINIATURIZED ANTENNA ELEMENT AND ARRAY

FIELD OF THE INVENTION

The present invention relates generally to the field of commercial antenna development for wireless internet services.

BACKGROUND OF THE INVENTION

The range and data rate of wireless internet services, as well as other forms of wireless data communications, depend on power, antenna gain, and signal bandwidth, among other factors. All three factors are limited both by economic and size considerations; furthermore, in the most commonly used frequency bands for unlicensed wireless internet services in the US, the 2400-2483.5 MHz ISM (industrial, scientific, and medical) band, as well as in the other unlicensed bands (e.g. 5725-5850 MHz), the transmitter power, transmitting antenna gain, and signal bandwidth are all directly or indirectly limited by federal regulations (Title 47, Part 15, Sec 15.247).

Current regulatory limits for point-to-multipoint communications (e.g. the base to client link when a base serves multiple clients) in the above mentioned bands require spread spectrum operation covering most of the frequency band, and an EIRP (effective isotropic radiated power) of no more than 36 dBm with a transmit power of no more than 30 dBm. Thus systems taking full advantage of the allowable parameter range need an antenna gain of at least 6 dBi. Systems with lower power transmitters need a higher antenna gain, for example, a 20 dBm transmitter is best operated a 16 dBi antenna. Current commonly used solutions for low gain (6-12 dBi) antennas in the ISM band are collinear verticals and corner reflector antennas. Common medium gain antennas (12-20 dBi) are arrays of dipoles and patches, with or without corner reflectors or backplates. For high gain antennas (> 20 dBi) parabolic reflectors are almost exclusively used.

The option of reduced transmit power with increased gain is desirable from a point of view of interference reduction, and also reduces the transmitter/power amplifier

cost. On the other hand, end users generally find smaller antenna size desirable, both for appearance, mounting, and safety concerns. Furthermore, lower gain antennas are simpler to align and less critical in their mounting accuracy.

The present invention addresses the need for antennas with reasonably high gain (12 to 24 dbi) that have reduced size, both in terms actual volume and in visual size as perceived from a distance, and greater ease in alignment and mounting, while still covering the entire required frequency range. Since electromagnetic principles show that smaller antennas generally have smaller gain and reduced bandwidth, innovative design techniques are needed to achieve a size reduction without impacting performance.

Furthermore, for a particular value of antenna gain, a fan beam with a narrow beamwidth in the horizontal plane and a relatively broad beamwidth in the vertical plane is desirable for three reasons. First, inteference sources/receptors have a tendency to appear distributed along the horizon as seen from the antenna. A narrow beamwidth in the horizontal plane will have significantly improved ability to discriminate between interference sources/receptors and the desired link, while the broad vertical beamwidth will sacrifice little in this respect. Second, having a broad beam in one plane means that accurate pointing is necessary only in the other plane. Thus, a greatly simplified mounting structure with only one degree of freedom is possible, improving both cost and rigidity. Third, since only one degree of freedom is available in the mounting initial alignment when the antenna is installed is simplified.

The present invention employs techniques including antenna folding, dielectric loading and end loading in a printed circuit format in order to reduce the size of the antenna, in particular the height when used as a vertical polarization radiator. The gain is achieved by employing both Yagi-Uda and broadside array techniques. The array configuration also yields a beam that is narrower in the horizontal plane than in the vertical plane. The combination of reduce size, ease of mounting, and interference reduction should be attractive and useful, particularly for client stations in a situation where multiple clients communicate with a base station.

SUMMARY OF THE INVENTION

It is one object of the invention to provide a low profile, reduced size antenna.

It is another object of the invention to provide reduced size dipole and monopole antennas, printed on one side of a substrate with slotted loading patches at the end(s) of the antenna, and a conducting strip on the reverse side to form a folded dipole or monopole structure.

It is another object of the invention to provide linear and/or broadsideYagi-Uda arrays of reduced size elements to form a directional antenna, with narrow beamwidth in one plane and broader beamwidth in another plane.

DETAILED DESCRIPTION OF THE INVENTION

1. The first component to be described is a reduced size printed dipole antenna element, as depicted in Figures 1 and 2. Figure 1 depicts the front side of the element, and Figure 2 depicts the reverse side. The reduced size printed dipole antenna element consists of a dielectric substrate (7), with patterned metallized regions (8) which can be formed by any of the processes commonly used to form printed circuits. The metallized regions on the front side form a linear, driven conductor (30) with a feed point (40) at the center, as well as end loading patches (20). Slots (50) are cut into the end loading patches in order to effectively extend the length of the linear driven conductor. Although the patches are shown as being rectangular in shape, similar performance can be obtained with other shapes, for example, round. The loading patches have the effect of lowering the first resonant frequency of the antenna for a given length; or, conversely, reducing the length required to obtain resonance at a given frequency. However, this length reduction, if used alone, tends to reduce the radiation resistance of the antenna, leading to poor impedance match and lower efficiency. It also decreases the bandwith. These effects can be compensated by the placement of a second, linear, undriven conductor (33) on the reverse

side of the substrate, connected to the driven conductor through vias holes (10) in the substrate. In the preferred embodiment, the via hole connections are at the ends of the antenna, to form a folded dipole. In other embodiments the position of the holes could be moved to another position along the antenna to modify the impedance. The folding effected as described increases the input impedance, and thus the radiation resistance. If the strips are of equal width the radiation resistance increases by a factor of four; by varying the widths different multiplication factors can be obtained. The strips also form a parallel strip transmission line with dielectric loading due the substrate. The dielectric has the effect of reducing the velocity of the transmission line. By proper selection of the dielectric constant and length of the antenna, the transmission line can be made antiresonant at the same frequency at which the antenna structure is resonant. The combination of the antiresonance and resonance allows the antenna to have a double-tuned response, and a bandwidth greatly improved over a simple resonant response.

In a typical design for operation at 2.45 GHz, the length of the antenna is 1.2 inches, the width of the conducting strip is 0. 16 inches, the patch measures 0.4 inches by 0.5 inches, and the slots are 0.02 inches wide by 0.16 inches long. The substrate is 0.031 inches thick with a dielectric constant of 4.7. However, modification of these dimensions is clearly possible to suit various applications; in particular, the design can be easily scaled to any operating frequency using formulas available in textbooks and known to skilled practioners. The antenna is typically half the length of a conventional antenna at this frequency.

2. The second component to be desribed is a reduced size printed monopole antenna element based on the same principles, the front side of which is depicted in Figure 3. It is identical to the reduced size printed dipole antenna element described above except that only half of the structure is used, and this half is mounted over a conducting ground plane (5), with plane of the antenna substrate (7) perpendicular to the conducting ground plane. The driven element (30) can be excited by a conductor (90) fed through the ground plane. The undriven element on the reverse side is connected directly to the ground plane. Again, by varying the relative widths of the two conducting strips the impedance level

can be adjusted, and by proper selection of the antenna length in combination with the dielectric constant of the substrate a broad double-tuned response can be obtained.

3. The third component to be described is a parasitic (also known as passive) reduced size printed dipole antenna element, the front side of which is depicted in Figure 4. The element is identical to the reduced size printed dipole antenna element described in part 1 above descibed above and shown in Figures 1 and 2, except that the second undriven conductor, the feed point, and the via holes are omitted. The reverse side needs no metallization and can be left completely bare of metal. A number of these parasitic reduced size printed dipole antenna elements can be used in conjunction with the reduced size printed dipole antenna element described in part 1 above and shown in Figures 1 and 2, to form Yagi-Uda type arrays, as will be described below. For use as a passsive reflecting element, the length is increased (typically by about 10 to 15%) over the length used in the driven element. For use as a passive directing element, the length is decreased (typically by about 10 to 15%) below the length used in the driven element.

4. The fourth component to be described is a parasitic (also known as passive) reduced size printed monopole antenna element. The element is identical to the reduced size printed monopole antenna element described in part 1 above descibed above and shown in Figures 1 and 2, except that the second undriven conductor, the feed point, and the via holes are omitted. The conducting element is connected directly to the ground plane. The reverse side needs no metallization and can be left completely bare of metal. A number of the parasitic reduced size printed monopole antenna elements can be used in conjunction with the reduced size printed monopole antenna element described in part 2 above and shown in Figure 3, to form Yagi-Uda type arrays, as will be described below. For use as a passsive reflecting element, the length is increased (typically by about 10 to 15%) over the length used in the driven element. For use as a passive directing element, the length is decreased (typically by about 10 to 15%) below the length used in the driven element.

5. The fifth item to be described is a Yagi-Uda type array formed from combinations of the elements described in the previous paragraphs. In the same manner as conventional dipoles and monopoles, the reduced size printed antenna elements described above can be combined in antenna arrays of any type, using methods that are be familiar to skilled practioners.

In one embodiment of the invention, depicted in Figure 5, the elements of the array are coplanar and can be conveniently printed on a single substrate (7). An enlarged version of the parasitic reduced size printed dipole element described in part 3 above is used as a reflecting element (3a), while one or more smaller versions of the same element are used as director elements (3b). A reduced size printed dipole element as described in part 1 above is placed between the reflecting element and the director elements and is used as the driven element (5). The spacing between the elements is typically about 0.2 wavelengths. The spacing can be varied in conjunction with the lengths of the reflector and director elements in order to adjust the gain, pattern, and frequency response of the antenna. Performance substantially comparable to conventional Yagi-Uda arrays is obtained, with a narrow beam radiated along the array axis in the direction of the director element and reduced radiation in the direction of the reflector element. A front-to-back ratio of 15 dB can be readily obtained.

In another embodiment, depicted in Figure 6, the elements are printed on separate substrates transverse to the array axis. Both configurations can yield a directive pattern with good front-to-back ratio.

It should be noted that both of the embodiments of the Yagi-Uda array can be implemented effectively using the monopole versions of the driven and parasitic elements, as described in parts 2 and 4 above.

6. The sixth item to be described is a broadside array formed from combinations of the elements described in the parts 1 through 4. A typical embodiment is shown in Figure 7, and consists of a number of driven reduced size printed dipole antenna elements (5) as described in part 1 positioned on a single substrate (7a). In the preferred embodiment the elements are spaced equally, typically with a spacing of not less than one-quarter and not

more than one-half wavelength; however, unequal spacings and spacings outside the typical range may be used.

A method for feeding the broadside array is depicted in Figures 8 and 9, with Figure 8 showing an overall view and Figure 9 a cross section detail. A second substrate (7b) is mounted perpendicular to the first substrate (7a), and has formed on it a metallized pattern of parallel strip transmission lines (70), that is, transmission lines with strips facing each other on either surface of the substrate. In the preferred embodiment, narrower and thus higher impedance transmission lines (72) are used to feed the outer elements and wider and thus lower impedance transmission lines (75) are used to feed the inner elements. By proper selection of the widths the impedances can be arranged such that substantially equal power is distributed to each element in the broadside array, and by proper selection of the line lengths, taking into account the dielectric constant of the substrate material (7b), the drive to each element can be made to be substantially in phase; the combination of equal power and phase giving high gain broadside radiation. By slight modifications of the widths, a tapered amplitude distribution can also be obtained to reduced sidelobe levels at the cost of reducing the gain. At the center, a perpendicular feed line (78) is added to step the overall impedance up to a level suitable for feeding from standard coaxial cables, using a connector mounted at a feed point (60). The transmission lines (72) and (78) are connected to the feed points of the driven elements (5) at the point where the antenna substrate (7a) and feed substrate (7b) join, typically though solder joints at the junctions, although any electrical connection type may be used.

The broadside array will yield a vertical fan-beam radiation pattern that is much more narrow in the horizontal plane that in the vertical plane. This will ease mounting and alignment difficulties in usage of antennas in applications such as client side radios in wireless networks, since the antenna mount only needs precision adjustment in one plane. Thus the antenna could be mounted on a simple pole that could be rotated to point it towards a base station. In a typical embodiment with four elements both substrates (7a) and (7b) have dielectric constant of about 4.0 and the spacing of the elements is approximately 0.5 free space wavelengths, with the narrower lines (72) having a characteristic impedance of about 100 ohms and the wider lines (75) having a

characteristic impedance of about 50 ohms, and the center feed line (78) having a characteristic impedance of about 37 ohms, resulting in a beamwidth of approximately 16 degrees.

7. The seventh item to be described is an array combining broadside and Yagi-Uda techniques. The array can take many different forms. Two particular embodiments are described here.

The first embodiment, shown in Figure 10, comprises three or more antenna substrates (7c, 7d, and 7e) and one feed substrate (7f). Substrates 7d and 7e form the broadside array described in the previous part. Substrate 7c has positioned on it a number of enlarged versions of the parasitic elements described in part 3, with spacings equal to that on substrate 7d, with each element on 7c serving as a reflector for the corresponding element on 7d. Substrate 7e has positioned on it a number of smaller versions of the parasitic elements described in part 3, with spacings equal to that on substrate 7d, with each element on 7c serving as a director for the corresponding element on 7d. Additional substrates with director elements of the type used in 7e can be added to extend the Yagi-Uda array effect.

The second embodiment, shown in Figure 11, comprises a number of single substrates (7g), each containing a Yagi-Uda array of the type shown in Figure 5. The individual arrays are placed such that the substrate planes are parallel but displaced, and distributed along an axis perpendicular to both the individual array axes and the redcued size printed dipole antenna elements themselves. A feed substrate (7h), substantially identical to the type described in part 6 and shown as 7b in Figure 8, is used to feed the individual arrays with approximately equal amplitude and phase, although the amplitudes could be tapered by modification of the feedline widths.

In both cases, the result is to obtain increased gain by combining the Yagi-Uda effect with the broadside array effect. Again, a narrow vertical fan beam can be obtained due to the broadside array, while the Yagi-Uda arrangement increases the forward gain and yields a high front-to-back ratio.

8. While the present invention has been described with reference to a few specific embodiments, the description is illustrative and is not to be construed as limiting the invention. Various modifications may occur to those skilled in the art without departing from the true spirit and scope of the invention as defined by the appended claims.

What is claimed is:

(1) A reduced size printed dipole antenna element comprising:

(a) A dielectric substrate,

(b) Two conducting patches on one side of said dielectric substrate,

(c) a conducting strip, narrower than the patches, connecting the two said conducting patches, with a feed point at the center,

(d) Slots cut into said conducting patches to effectively extend the length of the said conducting strip, and

(e) A second conducting strip on the reverse side of said dielectric substrate, forming a parallel strip transmission line with said conducting strip and connected to said conducting patches through the use of via holes in said dielectric substrate.

(2) A reduced size printed monopole antenna as in claim (1) further comprising a mounting on a ground plane, with said conducting strip driven and said second conducting strip connected to said ground plane.

(3) A parasitic reduced size printed dipole antenna element comprising:

(a) A dielectric substrate,

(b) Two conducting patches on one side of said dielectric substrate,

(c) a conducting strip, narrower than the patches, connecting the two said conducting patches; and

(d) Slots cut into said conducting patches to effectively extend the length of the said conducting strip.

(4) The parasitic reduced size printed monopole antenna as in claim (3) further comprising a mounting on a ground plane.

(5) A Yagi-Uda type directional array comprising:

(a) Any number of parasitic reduced size printed dipole antenna element of claim (3); and

(b) the reduced size printed dipole antenna of claim (1);

whereby number of parasitic reduced size printed dipole antenna element and said reduced size printed dipole antenna are positioned on a substrate.

(6) A broadside array comprising;

(a) a first substrate having any number of reduced size printed dipole antenna element; and

(b) a second substrate with a feed structure whereby said feedstructure consists of parallel strip transmission lines

whereby said first substrate is perpendicularly connected to said second substrate.

(7) A stacked broad side array comprising:

(a) the broad side array as described in claim (6)

(b)a number of parasitic broad side arrays each comprising a number of the parasitic reduced size printed dipole antenna elements of claim (3) whereby they are positioned on any side of said broad side array.

(8) A stacked array of the Yagi Uda arrays as described in claim (5) whereby said stach comprises of any numbers of said Yagi uda Arrays connected by a second substrate with a feed structure whereby said feedstructure consists of parallel strip transmission lines.

ABSTRACT OF THE DISCLOSURE

The invention consists of reduced size dipole and monopole antennas, printed on one side of a substrate with slotted loading patches at the end(s) of the antenna, and a conducting strip on the reverse side to form a folded dipole or monopole structure. The size of the structure is approximately half that of a conventional printed dipole or monopole, while maintaining or increasing the useful bandwidth. The antennas can be used in conjunction with simplified reflector and director elements to form Yagi-Uda arrays, as well as larger broadside arrays consisting of a number of Yagi-Uda arrays operated in conjunction to form a narrow fan beam. The arrays offer improved appearance due to reduced size, simpler mounting, and greater ease in alignment compared to arrays commonly in use for wireless networking.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION NUMBER: 09/882,703

FILING OR 371(c) DATE: 06/14/2001

FIRST NAME APPLICANT: HEINRICH FOLTZ

NOTICE OF CHANGE OF ADDRESS

Dear Sirs;

The attorney of record for the above referenced application has moved. Please update your records. The new address for all correspondence regarding the above referenced application should be as follows:

Anthony Matulewicz
Matulewicz & Associates, P.C.
3503 W. Alberta
Edinburg, Texas 78539
Phone (956) 972-0330
Facsimile (956) 972-0353

Respectfully Submitted,

Anthony Matulewicz
Patent Reg. No. 45,375.

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MINIATURIZED ANTENNA ELEMENT AND ARRAY

FIELD OF THE INVENTION

The present invention relates generally to the field of commercial antenna development for wireless internet services.

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BACKGROUND OF THE INVENTION

The range and data rate of wireless internet services, as well as other forms of wireless data communications, depend on power, antenna gain, and signal bandwidth, among other factors. All three factors are limited both by economic and size considerations; furthermore, in the most commonly used frequency bands for unlicensed wireless internet services in the US, the 2400-2483.5 MHz ISM (industrial, scientific, and medical) band, as well as in the other unlicensed bands (e.g. 5725-5850 MHz), the transmitter power, transmitting antenna gain, and signal bandwidth are all directly or indirectly limited by federal regulations (Title 47, Part 15, Sec 15.247).

Current regulatory limits for point-to-multipoint communications (e.g. the base to client link when a base serves multiple clients) in the above mentioned bands require spread spectrum operation covering most of the frequency band, and an EIRP (effective isotropic radiated power) of no more than 36 dBm with a transmit power of no more than 30 dBm. Thus systems taking full advantage of the allowable parameter range need an antenna gain of at least 6 dBi. Systems with lower power transmitters need a higher antenna gain, for example, a 20 dBm transmitter is best operated a 16 dBi antenna. Current commonly used solutions for low gain (6-12 dBi) antennas in the ISM band are collinear verticals and corner reflector antennas. Common medium gain antennas (12-20 dBi) are arrays of dipoles and patches, with or without corner reflectors or backplates. For high gain antennas (> 20 dBi) parabolic reflectors are almost exclusively used.

The option of reduced transmit power with increased gain is desirable from a point of view of interference reduction, and also reduces the transmitter/power amplifier cost. On the other hand, end users generally find smaller antenna size desirable, both for appearance, mounting, and safety concerns. Furthermore, lower gain antennas are simpler to align and less critical in their mounting accuracy.

The present invention addresses the need for antennas with reasonably high gain (12 to 24 dbi) that have reduced size, both in terms actual volume and in visual size as perceived from a distance, and greater ease in alignment and mounting, while still covering the entire required frequency range. Since electromagnetic principles show that

smaller antennas generally have smaller gain and reduced bandwidth, innovative design techniques are needed to achieve a size reduction without impacting performance.

Furthermore, for a particular value of antenna gain, a fan beam with a narrow beamwidth in the horizontal plane and a relatively broad beamwidth in the vertical plane is desirable for three reasons. First, inteference sources/receptors have a tendency to appear distributed along the horizon as seen from the antenna. A narrow beamwidth in the horizontal plane will have significantly improved ability to discriminate between interference sources/receptors and the desired link, while the broad vertical beamwidth will sacrifice little in this respect. Second, having a broad beam in one plane means that accurate pointing is necessary only in the other plane. Thus, a greatly simplified mounting structure with only one degree of freedom is possible, improving both cost and rigidity. Third, since only one degree of freedom is available in the mounting initial alignment when the antenna is installed is simplified.

The present invention employs techniques including antenna folding, dielectric loading and end loading in a printed circuit format in order to reduce the size of the antenna, in particular the height when used as a vertical polarization radiator. The gain is achieved by employing both Yagi-Uda and broadside array techniques. The array configuration also yields a beam that is narrower in the horizontal plane than in the vertical plane. The combination of reduce size, ease of mounting, and interference reduction should be attractive and useful, particularly for client stations in a situation where multiple clients communicate with a base station.

SUMMARY OF THE INVENTION

It is one object of the invention to provide a low profile, reduced size antenna.

It is another object of the invention to provide reduced size dipole and monopole antennas, printed on one side of a substrate with slotted loading patches at the end(s) of the antenna, and a conducting strip on the reverse side to form a folded dipole or monopole structure.

It is another object of the invention to provide linear and/or broadsideYagi-Uda arrays of reduced size elements to form a directional antenna, with narrow beamwidth in one plane and broader beamwidth in another plane.

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OCT 21 2004
OFFICE OF PETITIONS

DETAILED DESCRIPTION OF THE INVENTION

1. The first component to be described is a reduced size printed dipole antenna element, as depicted in Figures 1 and 2. Figure 1 depicts the front side of the element, and Figure 2 depicts the reverse side. The reduced size printed dipole antenna element consists of a dielectric substrate (7), with patterned metallized regions (8) which can be formed by any of the processes commonly used to form printed circuits. The metallized regions on the front side form a linear, driven conductor (30) with a feed point (40) at the center, as well as end loading patches (20). Slots (50) are cut into the end loading patches in order to effectively extend the length of the linear driven conductor. Although the patches are shown as being rectangular in shape, similar performance can be obtained with other shapes, for example, round. The loading patches have the effect of lowering the first resonant frequency of the antenna for a given length; or, conversely, reducing the length required to obtain resonance at a given frequency. However, this length reduction, if used alone, tends to reduce the radiation resistance of the antenna, leading to poor impedance match and lower efficiency. It also decreases the bandwith. These effects can be compensated by the placement of a second, linear, undriven conductor (33) on the reverse side of the substrate, connected to the driven conductor through vias holes (10) in the substrate. In the preferred embodiment, the via hole connections are at the ends of the antenna, to form a folded dipole. In other embodiments the position of the holes could be moved to another position along the antenna to modify the impedance. The folding effected as described increases the input impedance, and thus the radiation resistance. If the strips are of equal width the radiation resistance increases by a factor of four; by

varying the widths different multiplication factors can be obtained. The strips also form a parallel strip transmission line with dielectric loading due the substrate. The dielectric has the effect of reducing the velocity of the transmission line. By proper selection of the dielectric constant and length of the antenna, the transmission line can be made antiresonant at the same frequency at which the antenna structure is resonant. The combination of the antiresonance and resonance allows the antenna to have a double-tuned response, and a bandwidth greatly improved over a simple resonant response.

In a typical design for operation at 2.45 GHz, the length of the antenna is 1.2 inches, the width of the conducting strip is 0. 16 inches, the patch measures 0.4 inches by 0.5 inches, and the slots are 0.02 inches wide by 0.16 inches long. The substrate is 0.031 inches thick with a dielectric constant of 4.7. However, modification of these dimensions is clearly possible to suit various applications; in particular, the design can be easily scaled to any operating frequency using formulas available in textbooks and known to skilled practioners. The antenna is typically half the length of a conventional antenna at this frequency.

2. The second component to be desribed is a reduced size printed monopole antenna element based on the same principles, the front side of which is depicted in Figure 3. It is identical to the reduced size printed dipole antenna element described above except that only half of the structure is used, and this half is mounted over a conducting ground plane (5), with plane of the antenna substrate (7) perpendicular to the conducting ground plane. The driven element (30) can be excited by a conductor (90) fed through the ground plane. The undriven element on the reverse side is connected directly to the ground plane. Again, by varying the relative widths of the two conducting strips the impedance level can be adjusted, and by proper selection of the antenna length in combination with the dielectric constant of the substrate a broad double-tuned response can be obtained.

3. The third component to be described is a parasitic (also known as passive) reduced size printed dipole antenna element, the front side of which is depicted in Figure 4. The element is identical to the reduced size printed dipole antenna element described in part 1

above descibed above and shown in Figures 1 and 2, except that the second undriven conductor, the feed point, and the via holes are omitted. The reverse side needs no metallization and can be left completely bare of metal. A number of these parasitic reduced size printed dipole antenna elements can be used in conjunction with the reduced size printed dipole antenna element described in part 1 above and shown in Figures 1 and 2, to form Yagi-Uda type arrays, as will be described below. For use as a passsive reflecting element, the length is increased (typically by about 10 to 15%) over the length used in the driven element. For use as a passive directing element, the length is decreased (typically by about 10 to 15%) below the length used in the driven element.

4. The fourth component to be described is a parasitic (also known as passive) reduced size printed monopole antenna element. The element is identical to the reduced size printed monopole antenna element described in part 1 above descibed above and shown in Figures 1 and 2, except that the second undriven conductor, the feed point, and the via holes are omitted. The conducting element is connected directly to the ground plane. The reverse side needs no metallization and can be left completely bare of metal. A number of the parasitic reduced size printed monopole antenna elements can be used in conjunction with the reduced size printed monopole antenna element described in part 2 above and shown in Figure 3, to form Yagi-Uda type arrays, as will be described below. For use as a passsive reflecting element, the length is increased (typically by about 10 to 15%) over the length used in the driven element. For use as a passive directing element, the length is decreased (typically by about 10 to 15%) below the length used in the driven element.

5. The fifth item to be described is a Yagi-Uda type array formed from combinations of the elements described in the previous paragraphs. In the same manner as conventional dipoles and monopoles, the reduced size printed antenna elements described above can be combined in antenna arrays of any type, using methods that are be familiar to skilled practioners.

In one embodiment of the invention, depicted in Figure 5, the elements of the array are coplanar and can be conveniently printed on a single substrate (7). An enlarged

version of the parasitic reduced size printed dipole element described in part 3 above is used as a reflecting element (3a), while one or more smaller versions of the same element are used as director elements (3b). A reduced size printed dipole element as described in part 1 above is placed between the reflecting element and the director elements and is used as the driven element (5). The spacing between the elements is typically about 0.2 wavelengths. The spacing can be varied in conjunction with the lengths of the reflector and director elements in order to adjust the gain, pattern, and frequency response of the antenna. Performance substantially comparable to conventional Yagi-Uda arrays is obtained, with a narrow beam radiated along the array axis in the direction of the director element and reduced radiation in the direction of the reflector element. A front-to-back ratio of 15 dB can be readily obtained.

In another embodiment, depicted in Figure 6, the elements are printed on separate substrates transverse to the array axis. Both configurations can yield a directive pattern with good front-to-back ratio.

It should be noted that both of the embodiments of the Yagi-Uda array can be implemented effectively using the monopole versions of the driven and parasitic elements, as described in parts 2 and 4 above.

6. The sixth item to be described is a broadside array formed from combinations of the elements described in the parts 1 through 4. A typical embodiment is shown in Figure 7, and consists of a number of driven reduced size printed dipole antenna elements (5) as described in part 1 positioned on a single substrate (7a). In the preferred embodiment the elements are spaced equally, typically with a spacing of not less than one-quarter and not more than one-half wavelength; however, unequal spacings and spacings outside the typical range may be used.

A method for feeding the broadside array is depicted in Figures 8 and 9, with Figure 8 showing an overall view and Figure 9 a cross section detail. A second substrate (7b) is mounted perpendicular to the first substrate (7a), and has formed on it a metallized pattern of parallel strip transmission lines (70), that is, transmission lines with strips facing each other on either surface of the substrate. In the preferred embodiment, narrower and thus higher impedance transmission lines (72) are used to feed the outer

elements and wider and thus lower impedance transmission lines (75) are used to feed the inner elements. By proper selection of the widths the impedances can be arranged such that substantially equal power is distributed to each element in the broadside array, and by proper selection of the line lengths, taking into account the dielectric constant of the substrate material (7b), the drive to each element can be made to be substantially in phase; the combination of equal power and phase giving high gain broadside radiation. By slight modifications of the widths, a tapered amplitude distribution can also be obtained to reduced sidelobe levels at the cost of reducing the gain. At the center, a perpendicular feed line (78) is added to step the overall impedance up to a level suitable for feeding from standard coaxial cables, using a connector mounted at a feed point (60). The transmission lines (72) and (78) are connected to the feed points of the driven elements (5) at the point where the antenna substrate (7a) and feed substrate (7b) join, typically though solder joints at the junctions, although any electrical connection type may be used.

The broadside array will yield a vertical fan-beam radiation pattern that is much more narrow in the horizontal plane that in the vertical plane. This will ease mounting and alignment difficulties in usage of antennas in applications such as client side radios in wireless networks, since the antenna mount only needs precision adjustment in one plane. Thus the antenna could be mounted on a simple pole that could be rotated to point it towards a base station. In a typical embodiment with four elements both substrates (7a) and (7b) have dielectric constant of about 4.0 and the spacing of the elements is approximately 0.5 free space wavelengths, with the narrower lines (72) having a characteristic impedance of about 100 ohms and the wider lines (75) having a characteristic impedance of about 50 ohms, and the center feed line (78) having a characteristic impedance of about 37 ohms, resulting in a beamwidth of approximately 16 degrees.

7. The seventh item to be described is an array combining broadside and Yagi-Uda techniques. The array can take many different forms. Two particular embodiments are described here.

The first embodiment, shown in Figure 10, comprises three or more antenna substrates (7c, 7d, and 7e) and one feed substrate (7f). Substrates 7d and 7e form the broadside array described in the previous part. Substrate 7c has positioned on it a number of enlarged versions of the parasitic elements described in part 3, with spacings equal to that on substrate 7d, with each element on 7c serving as a reflector for the corresponding element on 7d. Substrate 7e has positioned on it a number of smaller versions of the parasitic elements described in part 3, with spacings equal to that on substrate 7d, with each element on 7c serving as a director for the corresponding element on 7d. Additional substrates with director elements of the type used in 7e can be added to extend the Yagi-Uda array effect.

The second embodiment, shown in Figure 11, comprises a number of single substrates (7g), each containing a Yagi-Uda array of the type shown in Figure 5. The individual arrays are placed such that the substrate planes are parallel but displaced, and distributed along an axis perpendicular to both the individual array axes and the redcued size printed dipole antenna elements themselves. A feed substrate (7h), substantially identical to the type described in part 6 and shown as 7b in Figure 8, is used to feed the individual arrays with approximately equal amplitude and phase, although the amplitudes could be tapered by modification of the feedline widths.

In both cases, the result is to obtain increased gain by combining the Yagi-Uda effect with the broadside array effect. Again, a narrow vertical fan beam can be obtained due to the broadside array, while the Yagi-Uda arrangement increases the forward gain and yields a high front-to-back ratio.

8. While the present invention has been described with reference to a few specific embodiments, the description is illustrative and is not to be construed as limiting the invention. Various modifications may occur to those skilled in the art without departing from the true spirit and scope of the invention as defined by the appended claims.

What is claimed is:

(1) A reduced size printed dipole antenna element comprising:

(a) A dielectric substrate,

(b) Two conducting patches on one side of said dielectric substrate,

(c) a conducting strip, narrower than the patches, connecting the two said conducting patches, with a feed point at the center,

(d) Slots cut into said conducting patches to effectively extend the length of the said conducting strip, and

(e) A second conducting strip on the reverse side of said dielectric substrate, forming a parallel strip transmission line with said conducting strip and connected to said conducting patches through the use of via holes in said dielectric substrate.

(2) A reduced size printed monopole antenna as in claim (1) further comprising a mounting on a ground plane, with said conducting strip driven and said second conducting strip connected to said ground plane.

(3) A parasitic reduced size printed dipole antenna element comprising:

(a) A dielectric substrate,

(b) Two conducting patches on one side of said dielectric substrate,

(c) a conducting strip, narrower than the patches, connecting the two said conducting patches; and

(d) Slots cut into said conducting patches to effectively extend the length of the said conducting strip.

(4) The parasitic reduced size printed monopole antenna as in claim (3) further comprising a mounting on a ground plane.

(5) A Yagi-Uda type directional array comprising:

(a) Any number of parasitic reduced size printed dipole antenna element of claim (3); and
(b) the reduced size printed dipole antenna of claim (1);

whereby number of parasitic reduced size printed dipole antenna element and said reduced size printed dipole antenna are positioned on a substrate.

(6) A broadside array comprising;
(a) a first substrate having any number of reduced size printed dipole antenna element; and
(b) a second substrate with a feed structure whereby said feedstructure consists of parallel strip transmission lines

whereby said first substrate is perpendicularly connected to said second substrate.

(7) A stacked broad side array comprising:
(a) the broad side array as described in claim (6)
(b)a number of parasitic broad side arrays each comprising a number of the parasitic reduced size printed dipole antenna elements of claim (3) whereby they are positioned on any side of said broad side array.

(8) A stacked array of the Yagi Uda arrays as described in claim (5) whereby said stach comprises of any numbers of said Yagi uda Arrays connected by a second substrate with a feed structure whereby said feedstructure consists of parallel strip transmission lines.

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ABSTRACT

The invention consists of reduced size dipole and monopole antennas, printed on one side of a substrate with slotted loading patches at the end(s) of the antenna, and a conducting strip on the reverse side to form a folded dipole or monopole structure. The size of the structure is approximately half that of a conventional printed dipole or monopole, while maintaining or increasing the useful bandwidth. The antennas can be used in conjunction with simplified reflector and director elements to form Yagi-Uda arrays, as well as larger broadside arrays consisting of a number of Yagi-Uda arrays operated in conjunction to form a narrow fan beam. The arrays offer improved appearance due to reduced size, simpler mounting, and greater ease in alignment compared to arrays commonly in use for wireless networking.